This page intentionally left blank.

THE

QUARTERLY JOURNAL

OF THE

GEOLOGICAL SOCIETY OF LONDON.

EDITED BY

THE ASSISTANT-SECRETARY OF THE GEOLOGICAL SOCIETY.

Quod si cui mortalium cordi et curæ sit non tantum inventis hærere, atque iis uti, sed ad ulteriora penetrare; atque non disputando adversarium, sed opere naturam vincere; denique non belle et probabiliter opinari, sed certo et ostensive scire; tales, tanquam veri scientiarum filii, nobis (si videbitur) se adjungant. —*Novum Organum, Præfatio.*

VOLUME THE FIFTY-THIRD.

1897.

LONDON:

LONGMANS, GREEN, AND CO.

PARIS: FRIED. KLINCKSIECK, 11 RUE DE LILLE; F. SAVY, 77 BOULEVARD ST. GERMAIN,
LEIPZIG: T. O. WEIGEL.

SOLD ALSO AT THE APARTMENTS OF THE SOCIETY.

MDCCCXCVII.

5. *The* Fauna *of the* Keisley Limestone.—Part II. Conclusion.[1]

By F. R. Cowper Reed, Esq., M.A., F.G.S. (Read November 18th, 1896.)

[Plate VI.]

OSTRACODA.

Of the rich fauna of ostracods which Prof. T. Rupert Jones[2] has described from Kildare I have, after careful search, been able to determine only the following two at Keisley :—

Primitia M'Coyi, Salter.

This is the form which many previous observers have recorded as *Cythere phaseolus* (His.), but it is a mistaken identification, as Prof. Rupert Jones (*loc. cit.*) has shown. The species is as abundant at Keisley as it is at Kildare.

Cythere Wrightiana, Jones.

This is a rare form at Keisley, only two or three specimens having so far been found.

BRACHIOPODA.

Obolella *cf.* nitens, Hisinger.

A small transversely-oval shell, with a longitudinal groove from the beak to the anterior margin, appears to belong to this Swedish species.[3] The shell is very thin, and marked with only a few concentric lines of growth ; the brachial valve, which here is alone preserved, is much flattened, has a small pointed beak near the margin, an almost straight hinge-line, and a distinct longitudinal groove running from the beak to the front edge. The brachial valve of this species figured by Lindström[4] corresponds very closely in shape and other characters with our Keisley specimen, but the pedicle-valves there delineated are subcircular, and described as shield-shaped, though the breadth is given as twice the length. The species is found in the *Trinucleus*-schists of Sweden. Our specimen measures 2 millim. in length and 3 in breadth.

Orbiculoidea, sp.

A small circular pedicle-valve, ornamented with rather coarse concentric striæ, and possessing a central elevated umbo whence a narrow external pedicle-groove is traceable to the margin, is the only representative of the genus that I have seen from this rock. The specimen is in the Woodwardian Museum.

[1] For Part I., see this Journal, vol. lii. (1896) pp. 407–437 & pls. xx.–xxi.
[2] Ann. Mag. Nat. Hist. ser. 4, vol. ii. (1868) p. 54, pl. vii.
[3] Hisinger, 'Lethæa Suecica,' Stockholm, 1837, p. 77 (*Atrypa? nitens*).
[4] 'Fragm. Silur.' (1880) pl. xiii. fig. 34.

It cannot be identified with *Discina gibba* (Lindstr.) of the *Leptæna*-Limestone, for that species has two small nodules below the apical foramen, and the beak of the pedicle-valve is subcentral and nearer the posterior than the anterior margin. Davidson [1] figures a small species of *Orbiculoidea* (*Discina*, Dav.), from Keisley, which is apparently distinct from that above described.

LINGULA ?, sp.

Prof. Harkness [2] records *Lingula brevis*? (Portl.) from the Keisley Limestone. I have seen the specimen thus identified at Carlisle, and am very doubtful about it. It might even not be a brachiopod at all, but a lamellibranch, like *Ambonychia*? *nux* (Lindstr.), which Lindström [3] figures and describes from the *Leptæna*-Limestone.

ORTHIS CALLIGRAMMA, Dalm.

This species is not common at Keisley.

ORTHIS CALLIGRAMMA, var.

In addition to specimens with the ordinary features of this well-known species, there has been found the imperfect brachial valve of an *Orthis* having the shape and appearance of typical individuals of this species, but furnished with thirty to forty rounded, straight, simple ribs of regular width, separated by interspaces which at the margin of the valve are more than double the breadth of the ribs, except near the hinge-line, where the last six or seven ribs are somewhat crowded together and of rather smaller size.

ORTHIS ACTONIÆ, Sowerby.

This is a rare species in the Keisley rock. Probably *Orthis Oswaldi* (Von Buch), which occurs in Stage F of the East Baltic provinces, is a synonym, as Schmidt [4] mentions. It is found also in the Kildare and *Leptæna*-Limestones.

ORTHIS (BILOBITES) BILOBA, Linn.

Though a characteristically Silurian species, this is not unknown from Ordovician beds, and Davidson [5] records its occurrence at Cefn Rhyddan and other places in Bala rocks. I have seen several well-preserved specimens from Keisley, two of which I found myself. It occurs in the *Leptæna*-Limestone.

ORTHIS (PLATYSTROPHIA) BIFORATA, Schlotheim.

A fairly common species at Keisley. The Kildare and *Leptæna*-Limestones and Schmidt's Stage F also contain it.

[1] 'Mon. Brit. Foss. Brach.,' vol. iii. (1864–71) pl. l. fig. 27.
[2] Quart. Journ. Geol. Soc. vol. xxi. (1865) p. 248.
[3] 'Fragm. Silur.' (1880) p. 17, pl. xiii. figs. 53, 54.
[4] 'On the Silurian (and Cambrian) Strata of the Baltic Provinces of Russia,' Quart. Journ. Geol. Soc. vol. xxxviii. (1882) p. 514.
[5] 'Mon. Brit. Foss. Brach.,' vol. iii. (1864–71) p. 206.

ORTHIS (DALMANELLA) TESTUDINARIA, Dalman.

Not very common at Keisley. It has not been recorded so far from the Kildare or the *Leptæna*-Limestone.

ORTHIS (DALMANELLA ?) *cf.* CONFERTA, Lindström.

Lindström [1] describes and figures a small species of *Orthis* from the *Leptæna*-Limestone under the name of *O. conferta*. Some specimens from Keisley appear to belong to it, agreeing in shape and surface-ornamentation.

ORTHIS *cf.* ARGENTEA, Hisinger.

I have but little doubt that this species of Hisinger's [2] occurs at Keisley, for several well-preserved shells show all the typical external features with the regular bifurcation of the ribs, but they are of rather large size. In Sweden it occurs in the *Trinucleus*-Schists.

ORTHIS (HEBERTELLA?) KEISLEYENSIS, sp. n. (Pl. VI. figs. 1, 1*a*, & 1*b*.)

This species is founded on a single pedicle-valve of a small specimen, but it shows characters so peculiar and distinct that a new specific name is not uncalled for.

The valve is transverse, with a semicircular outline. The depth at the umbo is nearly one-third of the total length. There is a very faint indication of a median sinus; the beak is small, and not curved over the hinge-line.

The hinge-line is straight, and there is a high, triangular, steeply inclined hinge-area. The surface of the valve is ornamented with about sixteen simple, straight, unforked, narrow, rounded ribs extending from the beak to the margin, with interspaces of quite double the width of the ribs.

The ribs and interspaces are crossed by strong, rounded, raised, equidistant, concentric lines, not lamellose; these give a distinct cancellated appearance to the surface.

The length of the valve is 5 millim., and its width 6 millim.

In the shape of the pedicle-valve and the characters of the hinge-area, this Keisley form resembles the species belonging to the group *Hebertella* of Hall & Clarke,[3] but none of the species, so far as I know, have a precisely similar ornamentation.

In these respects also the common Wenlock species, *Orthis Bouchardi* (Davidson), is not unlike our specimen, but it has fewer ribs and the concentric markings are lamellose.

ORTHIS VESPERTILIO, Sowerby.

There is a specimen in the Carlisle Museum from Keisley, but it is a rare form. It probably occurs at Kildare.

[1] 'Fragm. Silur.' (1880) p. 26, pl. xiii. figs. 1–3.
[2] *Ibid.* pl. xiv. figs. 12–15; and Hisinger, 'Lethæa Suecica' (1837), p. 72, pl. xx. fig. 15.
[3] 'Pal. N. Y.,' vol. viii. Brach. pt. i. (1892) p. 198.

ORTHIS (DALMANELLA) ELEGANTULA ?, Dalman.

ORTHIS (HETERORTHIS) ALTERNATA ?, Sowerby.

ORTHIS (DINORTHIS) FLABELLULUM ?, Sowerby.

These three species have been doubtfully identified from fragmentary specimens.

STROPHOMENA ANTIQUATA, Sowerby.

A fairly common species at Keisley; it is found in the Bala, as well as in the Silurian of Britain.

STROPHOMENA CORRUGATELLA, Davidson.

This is one of the commonest species at Keisley, and is also found at the Chair of Kildare and in the *Leptæna*-Limestone.

LEPTÆNA RHOMBOIDALIS, Wilckens.

This species, commonly but erroneously[1] called *Strophomena rhomboidalis*, is not abundant in the Keisley Limestone, but it has been recorded thence by Harkness, Marr, and Nicholson, and I have found good typical specimens of it myself. It occurs also in the Kildare Limestone and in the Dalecarlian Limestone.

PLECTAMBONITES SCHMIDTI, Törnquist.

It is of considerable importance that this species has been recognized at Keisley, for it appears to be nearly restricted to the horizon of the *Leptæna*-Limestone and Stage F of Schmidt. I have not seen any specimens from Kildare, but the Keisley examples show all the features described by Lindström.[2]

PLECTAMBONITES QUINQUECOSTATA, M'Coy.

Törnquist[3] compares a *Leptæna*-Limestone species with this one of M'Coy's, but it is not given in the 'List of the Fossil Faunas of Sweden' (Stockholm, 1888). It is fairly common at Keisley and Kildare.

PLECTAMBONITES TRANSVERSALIS ?, Wahlenberg.

I believe that this species occurs at Keisley, but the specimens are rather imperfect. It occurs also doubtfully at Kildare. It is known from Bala, Llandovery, and Wenlock rocks in the United Kingdom.[4]

RAFINESQUINA EXPANSA, Sowerby.

There is a well-preserved ventral valve of this species at Carlisle, and I have seen other fragments. Davidson[5] states that this form is found in the Caradoc and Lower Llandovery.

[1] Hall & Clarke, 'Pal. N. Y.,' vol. viii. Brach. pt. i. (1892) pp. 250 & 276.

[2] 'Fragm. Silur.' (1880) p. 29, pl. xiv. figs. 25, 26.

[3] 'Öfvers. ö. Bergbyggn. inom Siljans. i Dal.' p. 26, Sveriges Geol. Undersökn. ser. C, no. 57 (Stockholm, 1883).

[4] Davidson, 'Mon. Brit. Foss. Brach.,' vol. iii. (1864–71) p. 320 (*Leptæna transversalis*).

[5] *Ibid.* p. 314 (*Strophomena expansa*).

RAFINESQUINA DELTOIDEA, Dalman.

The typical form of this species occurs at Keisley, and perhaps at Kildare, but is rare. It is recorded from Stage F of the East Baltic provinces by Schmidt.[1]

RAFINESQUINA (?) DELTOIDEA, var. UNDATA, M'Coy.

This variety is not uncommon at Kildare and Keisley. I strongly doubt whether it is really a variety of *R. deltoidea* and not a distinct species belonging to another genus. Lindström[2] figures and describes a variety of *Strophēodonta imbrex* (Pander) which seems to be almost identical with the Keisley form. The latter agrees best with fig. 23, pl. xxxix. vol. iii. of Davidson's 'Monograph of the British Fossil Brachiopoda.' The Swedish specimens, however, which are from the *Leptæna*-Limestone appear to be less suddenly geniculated and to possess a greater number of larger ribs than those from Keisley and Kildare.

TRIPLECIA INSULARIS, Eichwald.

This species occurs at Keisley, Kildare, and in Stage F.

STREPTIS MONILIFERA, M'Coy.

This form appears to be almost restricted to Keisley and Kildare, where it is abundant.

CHRISTIANIA TENUICINCTA, M'Coy.

This is a very common species at Keisley, and is also found at Kildare. The peculiar internal structure and muscular impressions have recently led Messrs. Hall & Clarke to establish the new genus *Christiania* for the reception of this species, which previously was called a *Leptæna*.

ATRYPA EXPANSA, Lindström.

This species[3] is very variable, but is distinguished from *A. marginalis* (Dalm.) by its subquadrate form and diminished prominence of the beak of the ventral valve. Three fairly distinct varieties occur in the Keisley Limestone. The first (var. α) is characterized by the almost obsolete fold on the brachial valve, while the sinus on the pedicle-valve is fairly strong. The marginal fringes to the valves, such as Davidson figured in the case of *A. reticularis*, are frequently preserved.

The second variety (β) has the fold on the brachial valve distinct, but the ribs on the valves are much smaller and more numerous than in the type-form. Thus I have counted as many as ten ribs on the brachial fold of one specimen. The marginal fringes are often present in this variety also. The third variety (γ) is characterized by the possession of a strong angular sinus in the pedicle-valve,

[1] 'Rev. d. ostbalt. Silur. Trilob.,' pt. i. Mém. Acad Imp. des Sci. St. Pétersbourg, ser. 7, vol. xxx. (1881) no. 1, p. 38.
[2] 'Fragm. Silur.' (1880) p. 29, pl. xiv. figs. 27–32.
[3] *Ibid.* p. 22, pl. xii. figs. 6–10, 17–19.

furnished with a single median rib. The brachial valve has a low median fold, marked by two ribs and a somewhat wide interspace on each side between the fold and the lateral group of ribs. The cardinal angles of the shell are more rounded than in the type-form. I was at first inclined to remove this form into a new species, but perhaps it is safer at present merely to consider it a variety of *A. expansa*. It apparently occurs in the *Leptæna*-Limestone.

ATRYPA MARGINALIS (Dalman).

There is no reason to doubt that this species or a variety of it occurs in the Keisley Limestone, as its characters are sufficiently distinct from those of *A. expansa* in its typical form.

ATRYPINA SIMILIS, sp. n. (Pl. VI. figs. 2, 2 *a*, 2 *b*, 3, & 3 *a*.)

Shell small, subcircular, retziform, flattened. Pedicle-valve more convex than the brachial valve, and furnished with a prominent beak pierced by a distinct circular foramen with a deltidium (of one piece ?) in front. The surface of this valve is traversed by seven radiating rounded ribs extending from the beak to the margin ; of these the median one bifurcates close to the beak into two strong rounded ribs, each of which again bifurcates at about half its length. The other ribs are simple, and decrease in strength near the hinge-line.

Brachial valve flattened, more convex posteriorly, with small inconspicuous beak and shallow mesial sinus, widening anteriorly. In this sinus lies a single rounded rib which arises at a point about half the length of the shell and bifurcates into two weaker ribs which reach the margin. On each side of the sinus is a strong rounded rib, arising from the beak and bifurcating, at about half its length, into two weaker contiguous ribs reaching the margin like the central one in the sinus. (In the young form, Pl. VI. fig. 2 *a*, these ribs do not bifurcate.) On each lateral portion of the valve outside these ribs bordering the sinus are three simple ribs, those nearest the hinge-line being the weakest.

	millim.
Length of shell	5·5
Breadth „	5·0

This species much resembles *Atrypa Barrandei* (Davidson) [1] in shape and general characters, as well as in the distribution of the ribs on each valve. But it differs in the bifurcation of certain of these ribs and in the absence of the concentric-growth ridges.

Hall & Clarke [2] have recently designated the group of shells to which *Atrypa Barrandei* belongs by the generic term of *Atrypina*. Our Keisley species is especially closely allied to *A. disparilis* (Hall) [3] of the Niagara Group, and also much resembles the type of the genus *A. imbricata* (Hall) [4] from the Lower Helderberg Group.

[1] Davidson, 'Mon. Brit. Foss. Brach.,' vol. iii. (1864–71) p. 128, pl. xiii. figs. 10–13; vol. v. Suppl. Sil. Brach. (1882) p. 114, pl. vii. figs. 7–7 *b*.
[2] 'Pal. N. Y.,' vol. viii. Brach. pt. ii. (1894) p. 161.
[3] *Ibid.* vol. ii. (1852) p. 277, pl. lvii. fig. 6.
[4] *Ibid.* vol. iii. (1859) p. 246, pl. xxxviii. figs. 8–13.

But the distribution and furcation of the ribs are shown by the figures of these American species to be slightly different.

CAMERELLA ? THOMSONI (Davidson).

This species, which Davidson[1] doubtfully put in the genus *Rhynchonella*, resembles in external characters Billings's *Camerella Volborthi*[2] from the Black River Limestone of Canada and Törnquist's *Camerella angulosa*[3] from the *Leptæna*-Limestone. I think, therefore, that it is safer to assign it to the genus *Camerella* than to *Rhynchonella*, used in its old wide sense.

Davidson gives only Craighead Quarry and Penwhapple Glen as the localities in which this species has previously been found.

SYNTROPHIA AFFINIS, sp. n. (Pl. VI. figs. 4 & 4 *a*.)

Hall & Clarke[4] have recently established the new genus *Syntrophia* for a small group of brachiopods which externally resemble *Billingsella* and *Protorthis*, but in their internal structure are related to the genus *Stricklandinia* of a later date. A single pedicle-valve of a species of this genus *Syntrophia* from the Keisley Limestone is in the Woodwardian Museum, bearing a close resemblance to Whitfield's species *Syn. lateralis*, from the Calciferous formation of America. Our specimen is transversely elongate, strongly convex, with a straight hinge-line nearly equal to the greatest width of the shell. The valve is divided into two rounded convex lobes by a smooth sinus commencing a short distance in front of the umbo, and extending with increasing width to the anterior margin, which it gently sinuates. The umbo is small, not prominent, but incurved over the hinge-line. At the cardinal-lateral angles there is a slight flattening of the convexity of the lobes of the valve in the vicinity of the hinge-line. The surface of the valve is smooth, except for a few concentric striæ, of which the marginal ones are more strongly incised than the others.

As to the internal structure of the valve, the median septum is seen through the thin shell to extend forward from the beak for about two-thirds the length of the shell, but the spondylium formed by the dental plates is not visible.

The points in which our species differs from *Syn. lateralis* (Whitf.) are the inferior height and prominence of the umbo, and the more clearly defined and rounded median sinus.

	millim.
Length of shell	3
Breadth	5

RHYNCHOTREMA *cf.* DENTATUM, Hall.

The species *Rh. dentatum* occurs in the Trenton Limestone of

[1] 'Mon. Brit. Foss. Brach.,' vol. iii. (1864–71) p. 186, pl. xxiv. fig. 18.
[2] 'Canadian Naturalist & Geologist,' vol. iv. (1859) pp. 301, 302 & 445, figs. 23, 24.
[3] 'Om Lagerfolj. i Dal. undersilur Bildn.,' Lunds Universitets Årsskrift, vol. iii. (1866) p. 17; Lindström, 'Fragm. Silur.' (1880) p. 23, pl. xiii. figs. 14–19.
[4] 'Pal. N. Y.,' vol. viii. Brach. pt. ii. (1894) p. 216, pl. lxii. figs. 1–10.

America, from which it was first described by Hall[1] under the name of *Atrypa dentata*. Recently it has been assigned by Hall & Clarke[2] to the genus *Rhynchotrema*. The species much resembles *Rhynchonella*? *æmula* (Salter MS.) described by Davidson[3] from the Kildare Limestone, but in this Irish form the mesial fold of the brachial valve becomes biplicated only near the front margin of the shell, and the two short rounded ribs on each side of it are confined to the edges of the valve. In *Rh. dentatum*, on the other hand, the mesial fold is strongly biplicated nearly from the beak, while each lateral portion is furnished with three simple, slightly curved ribs, extending entirely from the beak to the margin. The 'zigzag filiform lines' which Hall describes in the American individuals are also distinguishable on the ribs of our specimen.

The American specimens appear to have rather sharper and more angular ribs than the Keisley form. This, however, is the only point of difference that I have been able to detect.

Davidson's *Rhynchonella decemplicata*,[4] from the Bala and Upper Llandovery beds, has more numerous ribs on the lateral portions, but otherwise, so far as external characters go, much resembles *Rhynchotrema dentatum*.

	millim.
Length of shell	4
Breadth	4

Dayia pentagonalis, sp. n. (Pl. VI. figs. 5, 5 *a*, 5 *b*, & 5 *c*.)

Shell subpentagonal, broadest across the middle, biconvex. Hinge-line curved. No hinge-area. Pedicle-valve more convex than the brachial valve, especially near the beak; beak closely curved over the hinge-line, concealing foramen. Beak of pedicle-valve furnished with a longitudinal, broad, rounded keel; at about one-third the length of the valve a shallow median furrow begins on this keel or ridge, and extends to the front margin, increasing in width anteriorly and thus making a double keel on the anterior portion of the valve. The lateral portions of the valve on the slopes of the median keel are slightly excavated, and are bounded posteriorly on each side by a small narrow fold starting from the side of the beak and curving round in its outward course to the end of the hinge-line, so as to give the appearance of a false hinge-area between it and the hinge-line, as in some Rhynchonellids.

The brachial valve is more convex posteriorly than towards the front margin. A shallow groove begins close in front of the umbo, and extends forward, with a steadily increasing width and depth, to the anterior edge of the shell, where it has a smooth flattened floor with low, steep, and abrupt sides. The lateral portions of this valve are gently convex.

The anterior margin of the shell is broadly notched, owing to the meeting of the median sinuses of the opposite valves. In the umbonal cavity of the pedicle-valve are seen two short, divergent,

[1] 'Pal. N. Y.,' vol. i. (1847) p. 148, pl. xxxiii. fig. 14.
[2] *Ibid.* vol. viii. Brach. pt. ii. (1894) p. 182.
[3] 'Mon. Brit. Foss. Brach.,' vol. iii. (1864–71) p. 188, pl. xxiv. fig. 21.
[4] *Ibid.* p. 177, pl. xxiii. figs. 20–24.

dental plates; and a long, low, median septum or ridge extends for about two-thirds of the length of the brachial valve.

A brachidium with spiral cones of the type of *Dayia* is present, but its details have not been made out, owing to lack of material on which to experiment.

	millim.
Length of shell	8·5
Breadth „	8·0

Affinities.—The extraordinarily close external resemblance of this species to Emmons's *Cyclospira bisulcata* [1] of the Trenton Limestone led me at first to the view that it must belong to the same genus. With the exception of the absence of the median fold in the sinus of the brachial valve, the resemblance appears to be complete. But on developing the interior of the shell I have been able to demonstrate that the brachidium is of the type of *Dayia navicula*, which is entirely different from the American genus *Cyclospira*, as Hall & Clarke have recently shown.[3]

I do not know whether Törnquist's species *Dayia pentagona* (MS.)[4] is synonymous, as no description or figure has been published. But the latter species is from the *Leptæna*-Limestone, and I have seen specimens of the form which I have above described from the same rock. There is a specimen of this shell from the Chair of Kildare Limestone, labelled *Atrypa navicula* (var.), in Sir R. Griffith's Collection in the Dublin Museum.

Hyattella Portlockiana (Davidson).

Davidson described this species more than 25 years ago from the Limestone of the Chair of Kildare,[5] and subsequently (in his Supplement to the Silurian Brachiopoda) from the Upper Llandeilo of Balcletchie, Girvan. The external characters of the shell were alone given, and it was assigned doubtfully to the genus *Rhynchonella*. Lindström [6] placed it in the genus *Athyris*, but does not mention his reasons for so doing. I have been able to expose the internal structure with some completeness, and to demonstrate the presence of spiral lamellæ, necessitating the removal of this species both from the genus *Rhynchonella* and from the genus *Athyris*.

There are two fairly distinct varieties of this species—a long one and a broad one. The elongated ovate form is that figured by Davidson; those illustrated by Lindström are rather broader and more globose, and pass into the transverse or broad variety. Inter-

[1] 'Geol. New York,' Rept. Second Distr. (1842) p. 395, fig. 4 (*Orthis bisulcata*); Hall, 'Pal. N. Y.,' vol. i. (1847) p. 139, pl. xxxiii. fig. 3 (*Atrypa bisulcata*); Hall & Clarke, *ibid.* vol. viii. Brach. pt. ii. (1894) p. 146 (*Cyclospira bisulcata*).

[2] Davidson, 'Mon. Brit. Foss. Brach.,' vol. iii. (1869) p. 190, pl. xxii. figs. 20–23; vol. v. Suppl. Sil. Brach. (1882) p. 96, pl. v. figs. 1–4.

[3] 'Pal. N. Y.,' vol. viii. Brach. pt. ii. (1894).

[4] E. Stolley, 'Die cambrischen u. silurischen Geschiebe Schleswig-Holsteins,' Archiv für Anthrop. u. Geol. Schl.-Holst., vol. i. pt. i. (1895) p. 88.

[5] 'Mon. Brit. Foss. Brach.,' vol. iii. (1869) p. 189, pl. xxiv. figs. 23–25; vol. v. Suppl. Sil. Brach. (1882) p. 159, pl. x. figs. 12–14.

[6] 'Fragm. Silur.' (1880) p. 22, pl. xiii. figs. 20–22.

nally, the characters of these varieties appear to be identical. The small subcircular, flattened forms which Davidson figures (*op. supra cit.* fig. 25), and which I have also found at Keisley, are probably only young individuals of the species. In these the median dorsal fold is more sharply defined posteriorly than in the other forms. The description of the species is as follows :—Shell longitudinally to transversely ovate, subglobose. Hinge-line curved. Cardinal angles rounded. Pedicle-valve the larger, with prominent beak incurved over the hinge-line; a weak median sinus is present in this valve—narrow near the beak, but increasing in width and depth anteriorly; a slight fold borders it on each side, and in some individuals a faint median ridge occurs in it. Brachial valve less convex than the ventral; beak small, and hidden beneath the incurved beak of the other valve. A low subquadrate fold with steep sides exists in this valve and corresponds to the sinus in the pedicle-valve; the fold is indistinct posteriorly in the adult and old individuals, but strongly developed on the anterior edge, where a deep sinus borders it on each side.

The surface of the valves is smooth, or decorated with very delicate radiating striæ (?).

A pair of short, subparallel, dental lamellæ is seen in the umbonal cavity of the pedicle-valve, and a strong muscular impression lies between them.

In the brachial valve a short septum exists, extending for about one-fifth of the length of the valve. The crural plates (seen in the course of developing one specimen) are triangular, and divided by a narrow deep median cleft exactly as figured in *Hyattella congesta* (Conr.).[1] The crura themselves are short, as in that species also. The primary lamellæ run forward with a steady divergence of from 25° to 30°, with no outward and only a slight upward curvature. The points and manner of attachment of these lamellæ have not been seen. They extend forward for more than two-thirds of the length of the valve, and then are coiled into the spiral cones. These cones consist of only four or five volutions, and form very loose coils. Their bases are subparallel to the longitudinal axis the shell, and their apices are directed laterally and slightly backward and downward into the pedicle-valve.

The loop has not been satisfactorily or clearly exposed; but it seems to arise at a point about halfway along the primary lamellæ, and to make a very acute angle with them, running backward with an upward curvature. At the angle where its lateral branches unite a strong single median process—apparently tubular—is given off, and rises abruptly in an upward direction to the level of the primary lamellæ. The point of this process is seen as a central dot between them in grinding down the brachial valve.

	millim.	millim.
Length of shell	10	9
Breadth „	15	8·5

[1] Hall & Clarke, 'Pal. N. Y.,' vol. viii. Brach. pt. ii. (1894) p. 61, pl. xl. figs. 23–28.

Affinities.—This species I would assign to the genus *Hyattella*, which Hall & Clarke have recently established (*loc. cit.*). In external characters *H. Portlockiana* agrees very closely with Conrad's *H. congesta* from the Clinton Group, and in its internal features the loose spiral coils, with their few volutions, position, and shape, the course of the primary lamellæ, the shape of the hinge-plate, with its narrow median cleft and short crura, the deep and striated pedicle-cavity in the pedicle-valve, with strong short dental plates, and the loop and process, so far as can be made out, are essentially similar. The chief points of difference are the presence of the short median septum in the brachial valve, and the greater length of the process of the loop.

This species (*H. Portlockiana*) is found in the *Leptæna*-Limestone in tolerable abundance.

POLYZOA.

PTILODICTYA COSTELLATA, M'Coy ?

PTILODICTYA RECTA, Hall ?

These two species are doubtfully recorded from Keisley.

FENESTELLA ASSIMILIS, Lonsdale.

Not very common.

MOLLUSCA.

Cephalopoda.

ORTHOCERAS *cf.* SCABRIDUM (Ang.).

Some fragmentary specimens from Keisley resemble this species of Angelin's [1] in their cylindrical shape, with a very slow rate of tapering, in the great distance apart of the septa (*i. e.* 1 to $1\frac{1}{3}$ the diameter of the shell), in the deep cup-shape of the septa, in the central siphuncle, and, as far as can be seen, in the ornamentation of the surface of the shell.

O. scabridum, in Sweden, is found in the *Orthoceras*-Limestone.

Foord [2] mentions that, in addition to *O.* cf. *elongatocinctum* (Portl.), another species occurs in the Keisley Limestone, and he may be referring to *O.* cf. *scabridum*.

ORTHOCERAS *cf.* ELONGATOCINCTUM (Portl.).

Foord (*loc. cit.*) describes this species from Keisley, where it is the commonest *Orthoceras*, and in some parts of the limestone occurs in abundance almost to the exclusion of other fossils.

[1] Lindström, 'Fragm. Silur.' (1880) p. 4, pl. iv. figs. 6–9 & pl. vii. figs. 8–10.
[2] Quart. Journ. Geol. Soc. vol. xlvii. (1891) p. 526.

Gasteropoda.

LOXONEMA STRIATISSIMUM, Salter MS. (Pl. VI. fig. 6.)

Shell elongate, turriculate, consisting of nine or ten whorls. Apical angle about 20°. Whorls ventricose, about twice as broad as long, the successive whorls regularly decreasing in size towards the apex by one-third of their length and breadth. Upper whorls constricted just below the suture. The suture-line crosses the axis of the shell at an angle of about 70°. Surface of shell ornamented with fine longitudinal curved lines.

There are specimens of this shell from the Kildare Limestone, and it is one of these in the Jermyn Street Museum which bears the MS. name *L. striatissimum*. It was probably given by Salter. *L. sinuosum* (Sowerby) [1] is a closely-allied species, and so is *L. intumescens* (Lindström),[2] but they possess strongly-bent striæ on the whorls. *L. dalecaricum* (Lindström),[3] of the *Leptæna*-Limestone, has whorls too globose and short to be considered identical with the Keisley form.

HOLOPEA CONCINNA, M'Coy.

This species is found at Keisley, and is said to be very abundant at the Chair of Kildare.[4] There are specimens of it from the latter locality in Sir R. Griffith's Collection in the Dublin Museum.

HOLOPEA STRIATELLA, Sowerby.

Casts of this species are not uncommon at Keisley. I have been unable to assign to it definitely any specimens from Kildare.

CYCLONEMA RUPESTRE, Eichwald.

This species is found at Kildare, and I have seen a portion of a single shell from Keisley in the Carlisle Museum, where it was labelled *Holopea concinna*. It is not recorded from the *Leptæna*-Limestone, but Schmidt [5] gives it as *Trochus rupestris* in his list of fossils from the Lyckholm-bed (Stage F).

CYCLONEMA SULCIFERUM, Eichw.

Of this shell I have seen only one imperfect specimen from Keisley. It occurs in the Kildare Limestone, and in the *Orthoceras*-Limestone of Esthonia.

EUNEMA CARINATUM, Lindström, var.

The only point of difference between a specimen from Keisley and that figured by Lindström [6] from the *Leptæna*-Limestone is

[1] 'Sil. Syst.' pt. i. (1839) p. 619, pl. viii. fig. 15 (*Terebra*).
[2] 'Sil. Gastrop., etc. Gotland,' K. Svensk. Vetensk. Akad. Handl. vol. xix. (1884) no. 6, p. 143, pl. xv. fig. 6.
[3] 'Fragm. Silur.' (1880) p. 14, pl. xv. fig. 19.
[4] M'Coy, 'Syn. Sil. Foss. Irel.' Dublin, 1846, p. 13, pl. i. fig. 10.
[5] 'Rev. ostbalt. silur. Trilob.,' pt. i. Mém. Acad. Impér. d. Sci. St. Pétersbourg, ser. 7, vol. xxx. (1881) no. 1, p. 38.
[6] *Op. jam cit.* p. 14, pl. xv. fig. 20.

that the apical angle is rather larger, giving consequently a broader and shorter form to the shell. The seven ventricose whorls furnished with three revolving carinæ are apparently quite similar to those in the Dalecarlian individuals.

EUOMPHALUS *cf.* OBTUSANGULUS, Lindström.

There are several small specimens of an *Euomphalus* in the state of casts, which may well be compared with Lindström's species *E. obtusangulus*,[1] but they are not sufficiently well preserved to admit of any positive statement as to their specific identity. *E. obtusangulus* is a *Leptæna*-Limestone species.

EUOMPHALUS NITIDULUS, Lindström?

I have little doubt that the fossil which is here referred with a query to Lindström's[2] species from the *Leptæna*-Limestone will ultimately be found really identical with it. It appears very similar to Billings's *Straparollus Hippolyta*.[3]

EUOMPHALUS SUBSULCATUS (His.)?

There is a portion of a shell in the Carlisle Museum which may belong to this species, quoted by M'Coy[4] as common in the Chair of Kildare Limestone. The fragment that I have seen is merely part of a shell coiled in a flat spiral, with several carinæ running round the whorls.

PLATYCERAS VERISIMILE, sp. n. (Pl. VI. figs. 7, 7 *a*, & 7 *b*.)

Shell neritiform, transverse, about twice as broad as high; spire low and short; of three or four whorls rapidly decreasing in size. Body-whorl very large, twice as broad as high, and nearly three times as large as the succeeding whorl. Suture only slightly impressed. Surface of shell ornamented with fine longitudinal lines which are rather irregular in size and very slightly sigmoidal.

This species much resembles the Swedish form *Pl. caniculatum* (Lindström),[5] but its sutural line is not so deeply impressed nor is its body-whorl so long. The mouth of the shell is not preserved. The ornamentation is different from that of *Pl. cornutum* (Hisinger),[6] which it otherwise resembles. The American species *Platyostoma niagarense*[7] appears to show much the same characters.

PLATYCERAS *cf.* CORNUTUM, Hisinger.

This very variable species is held to be synonymous with *Natica parva* (Sowerby), and with several other British species. Our specimen resembles most closely the species of Sowerby's just

[1] 'Fragm. Silur.' (1880) p. 12, pl. xvii. figs. 19–20.
[2] *Ibid.* p. 12, pl. xv. figs. 24–26.
[3] 'Geol. of Canada: Palæoz. Foss.,' vol. i. p. 160, fig. 144.
[4] 'Syn. Silur. Foss. Irel.' (1846) p. 14.
[5] *Op. jam cit.* pl. xvii. figs. 13–16.
[6] 'Lethæa Suecica' (1837) p. 41, pl. xii. fig. 11 (*Pileopsis cornuta*).
[7] Hall, 'Pal. N.Y.,' vol. ii. (1852) p. 287, pl. lx. figs. 1 *a–v*.

Page Unavailable

cation of our specimen with *C. elongata* is correct. It does not appear to agree with any of Holm's Swedish species.[1]

HYOLITHUS TRIANGULARIS ? (Portl.).

Prof. Harkness recorded this species from Keisley, and a specimen so labelled is in the Carlisle Museum. I am doubtful as to the correctness of this identification, for the rate of tapering of this specimen is more rapid, and, unless we regard it as the broken pointed end of the shell, it is a much shorter form than that figured by Portlock [2] and in Murchison's 'Siluria.' [3]

Lamellibranchiata.

PTERINÆA SUBFALCATA, Conrad, var.

Shell obliquely oval, subfalcate, narrow, strongly convex; umbo gibbous, acute, projecting above hinge-line. Surface ornamented with regular, simple, radiating, straight, fine ribs, of which the anterior ones are slightly curved forward. Anterior ear small, flat, triangular, sharply marked off from the body of the shell, striated. Posterior wing not preserved, but apparently as abruptly defined from the body of the shell as the anterior ear.

	millim.
Length of shell (obliquely measured)	10·5
Width of same across middle	7·0

This shell, which is in the Carlisle Museum, was labelled, apparently by Harkness, as *Pterinæa tenuistriata*; its shape and ornamentation are, however, completely different. It differs from typical specimens of *Pt. subfalcata* (Conrad) [4] only by the absence of the concentric striæ. The type-form of the species occurs in the Upper Ludlow.

ANODONTOPSIS, sp. (Pl. VI. figs. 9 & 9 *a*.)

Shell small, subcircular, gently convex, most convex near the beak; hinge-line slightly curved; beak near the anterior end, directed forward. The beak rises steeply above a small flattened portion immediately in front of it. No muscular scars or pallial line visible. Length 4·5 millim.

M'Coy's *Anodontopsis bulla* [5] appears to bear resemblance to this Keisley form, but it is with some hesitation that I refer the latter to the same genus, since it hardly shows sufficient structural features

[1] 'Sveriges Kambr. Silur. Hyolithidæ o. Conulariidæ,' Sver. Geol. Undersökn. ser. C, no. 112 (1893).
[2] 'Rep. Geol. Londond.' (1843) p. 375, pl. xxviii. A, figs. 3 *a–c*.
[3] 5th ed. p. 199, Foss. 41, fig. 2.
[4] M'Coy, 'Syst. Descr. Brit. Pal. Foss.' (1855) p. 263, pl. i. I, fig. 3.
[5] *Ibid.* p. 271, pl. i. K, figs. 11–13.

to allow of one's feeling sure of its affinities. Murchison's species *Lucina* ? *Hisingeri*,[1] from Gotland, also bears comparison with our form.

Modiolopsis ?, sp.

Harkness recorded *Modiolopsis Nerei* (Münster) from Keisley.[2] There is a specimen in the Woodwardian Museum with that name attached to it, but it is a mere fragment, and, in addition to feeling sure that this identification is erroneous, I have grave doubts even about the genus to which it should be referred. The anterior portion of a left (?) valve, probably of a circular shape when perfect, with a small inconspicuous beak some distance from the anterior (?) border of the shell, with the surface ornamented with concentric striæ—these are all the characters visible, and they are quite inadequate for identification.

ECHINODERMATA.

Cystidea.

Sphæronites pyriformis (Forbes).

Forbes describes this species as *Caryocystites pyriformis*[3] from the Chair of Kildare, but none of his specimens showed the arrangement of the plates. Our specimen, though imperfect, shows distinctly five tiers of large pentagonal or hexagonal plates somewhat irregularly arranged, but it is too incomplete to allow of any certainty as to the number or position of the plates in each tier. There are, however, five basal plates to be made out, and these with three lateral tiers and the summit-plates compose the test. The length of our specimen is about 18 millim.

The species has also been recorded from Rhiwlas.[4]

Crinoidea.

Only portions of the stems of various crinoids[5] have so far been found in the Keisley Limestone. Consequently, it is impossible with this unsatisfactory material to determine the genera and species; as there are, however, several well-marked types of stems which

[1] Quart. Journ. Geol. Soc. vol. iii. (1847) p. 24, woodcut; F. Römer, 'Leth. Errat.,' p. 87, pl. vi. fig. 7, & p. 101, pl. viii. fig. 2 (Palæont. Abhandl. ii. 1885).

[2] Quart. Journ. Geol. Soc. vol. xxi. (1865) p. 249.

[3] Mem. Geol. Surv. vol. ii. pt. ii. (1848) p. 515, pl. xxi. fig. 1.

[4] *Ibid.* vol. iii. 2nd ed. (1881) p. 476.

[5] Holm mentions crinoidal remains from the *Leptæna*-Limestone, Sver. Geol. Undersökn., ser. c, no. 115, pp. 14, 15 (Stockholm, 1890).

may at some future date be found associated with the calices, a brief description of them will be useful.

One type (α) consists of thin circular ossicles furnished with a strong rounded projecting ridge on the periphery, occupying rather more than one-third of the width.

Another common type (β) is composed of large, plain, smooth ossicles, unornamented, and all of equal size, forming a regular, smooth, cylindrical column.

Yet another type (γ) is quadrangular in section, and composed of alternating thick and thin ossicles with a large central canal.

A fourth type (δ) consists of circular ossicles, with a thickness of about one-fourth of the diameter of the stem, and all of the same size. A narrow, smooth, marginal ring surrounds the front edge, and a series of fine concentric lines with a single median circlet of tubercles adorn the rest of the periphery. There is a large central canal, with the margins radially striated.

Another type (ϵ) is composed of circular thick ossicles of equal size, with a rounded periphery ornamented with eight or nine longitudinally-elongated tubercles. The central canal is very small.

A sixth type (ζ) of stem shows a pentagonal section with a central canal of about one-fourth the diameter of the stem. And finally there is another type (η), which has a circular section, and is composed of thin ossicles ornamented with encircling threads swelling into irregularly-disposed low tubercles.

ACTINOZOA.

Streptelasma europæum, F. Römer.

This species seems to be the commonest coral at Keisley. It occurs also in the Borkholm [1] and Lyckholm zones,[2] in the Sadewitz drift-pebbles,[3] and is common in the Craighead Limestone.[4]

Halysites catenularia, L.

In England this species ranges from the Bala to the Silurian. I have seen only one specimen from Keisley. It occurs also in the Kildare Limestone, in the *Leptæna*-Limestone, and in the Lyckholm zone.[5]

[1] W. Weissermel, 'Die Korallen d. Silurgesch. Ostpreuss.,' Zeitschr. d. Deutsch. geol. Gesellsch. vol. xlvi. (1894) p. 580.

[2] Fr. Schmidt, 'Rev. d. ostbalt. Silur. Trilob.,' pt. i. Mém. Acad. Imp. des Sci. St. Pétersbourg, ser. 7, vol. xxx. (1881) no. 1, p. 38.

[3] F. Römer, 'Die foss. Fauna d. Silur. diluv. Gesch. v. Sadewitz,' Breslau, 1861, p. 16, pl. iv. fig. 1.

[4] Nicholson & Etheridge, 'Mon. Silur. Foss. Girvan,' 1878, p. 76, pl. vi. figs. 1, 1 *b*.

[5] Weissermel, *op. supra cit.* p. 661.

HELIOLITES DUBIA, Schmidt?

As far as one can judge from the external aspect, size, and arrangement of the corallites in a small fragment of a corallum, this species occurs at Keisley. Schmidt[1] describes it from the Lyckholm Beds, Lindström[2] from the *Leptæna*-Limestone, F. Römer[3] from the Sadewitz pebbles,[3] and Weissermel[4] from those of Rosenberg.

STENOPORA FIBROSA, Goldf.

This species is of common occurrence at Keisley and Kildare.

FAVOSITES ALVEOLARIS, Goldf., *pars*.

The Geological Survey of Ireland record this species from the Chair of Kildare, and it may be identical with the variety of the allied *F. aspera* said by Schmidt to occur in the Borkholm zone. *F. aspera*[5] has smaller corallites with greater irregularity of size.

PRASOPORA GRAYÆ, Nich. & Eth.

Prof. H. A. Nicholson, to whom I am indebted for kind assistance in this group of organisms, informs me that he has found this species at Keisley. In his work 'Palæozoic Tabulate Corals,' he says (p. 327): 'The only known species of *Prasopora* [i.e. *Pr. Grayæ*] occurs commonly in the Craighead Limestone (Lower Silurian) of Craighead, near Girvan, Ayrshire.'

Note.—In addition to the above-mentioned species, there are several indeterminable zaphrentoid corals and monticuliporoids in the Keisley Limestone. Harkness recorded *Nebulipora lens* from this rock, but the specimen thus labelled in the Carlisle Museum is very indistinct and doubtful.

[1] 'Untersuch. üb. d. Silur. Form. Ehstland, etc.' (1858) p. 228.
[2] 'Fragm. Silur.' (1880) p. 32, pl. i. figs. 1–4.
[3] 'Die foss. Fauna d. Silur. diluv. Gesch. v. Sadewitz' (1861), p. 26, pl. iv. fig. 5.
[4] Zeitschr. d. Deutsch. geol. Gesellsch. vol. xlvi. (1894) p. 666 & pl. liii. fig. 4.
[5] Edwards & Haime, 'Brit. Foss. Corals,' Monogr. Pal. Soc. (1850–1855) p. 257, pl. lx. figs. 3 & 3*a*.

List of Fossils from the Keisley Limestone

(showing also the species occurring in the Kildare Limestone, etc.).

Genera and Species.	Kildare Limestone.	*Leptæna*-Limestone.	Stage F.	
			Borkholm Zone.	Lyckholm Zone.
Trilobita.				
Agnostus cf. *galba*, Billings				
Ampyx binodulosus, n. sp.				
Tiresias insculptus, M'Coy	*			
Remopleurides Colbi, Portlock				
,, *longicostatus*, Portlock	*			
Cyphoniscus socialis, Salter	*			
Calymene Blumenbachi, var. *Caractaci*, Salter				
Homalonotus ? *punctillosus*, Törnquist	*	*		
Illænus Bowmani, Salter	*			
,, ,, var. *brevicapitatus*	*			
,, ,, var. *longicapitatus*				
,, *fallax*, Holm	*	*		
,, *Rœmeri*, Volborth	?	*	*	*
,, *cæcus*, Holm	?	...	...	*
,, *galeatus*, sp. n.				
,, sp. (hypostome)	*			
Cheirurus bimucronatus, Murchison	*			
,, *cancrurus*, Salter	*			
,, *keisleyensis*, sp. n.	*			
,, cf. *glaber*, Angelin	...	*	...	*
? ,, cf. *clavifrons*, Dalman	?			
,, (*Pseudosphærexochus*) *conformis*, Angelin	*	*	*	*
,, ,, *subquadratus*, sp. n.	?			
? *Sphærocoryphe granulata*, Angelin	?	*	?	
Sphærexochus mirus, Beyrich	*	*	*	*
,, *latirugatus*, sp. n.	*			
Staurocephalus Murchisoni, Barrande	*			
Acidaspis convexa, sp. n.				
,, sp.				
Lichas affinis, Angelin	...	*		
,, *bifurcatus*, n. sp.	?			
,, *bulbiceps*, Phillips MS.	*			
,, *conformis*, Ang.	...	*		
,, ,, var. *keisleyensis*				
,, *hibernicus*, Portlock	*			
,, *laxatus*, M'Coy	*	*		
Cyphaspis ? *Harknessi*, sp. n.				
,, (*Törnquistia*) *Nicholsoni*, sp. n.	*			
Phillipsinella parabola, Barrande				
Harpes Wegelini, Angelin	*	*		
? ,, *costatus*, Angelin	...	*		
,, sp. α				
,, sp. β				

List of Fossils (*continued*).

Genera and Species.	Kildare Limestone.	*Leptæna*-Limestone.	Stage F.	
			Borkholm Zone.	Lyckholm Zone.
Ostracoda.				
Primitia M'Coyi, Salter	*			
Cythere Wrightiana, Jones	*			
Brachiopoda.				
Orthis calligramma, Dalman	*	*		
„ „ var.	*			
„ *Actoniæ*, Sowerby	*	*	...	*
„ *vespertilio*, Sowerby	*			
„ (*Bilobites*) *biloba*, Linné	...	*		
„ (*Platystrophia*) *biforata*, Schlotheim	*	*	*	*
„ (*Dalmanella*) *testudinaria*, Dalman	?			
„ (? „) cf. *conferta*, Lindström	...	*		
„ (? „) cf. *argentea*, Hisinger				
„ („) *elegantula*, Dalman				
? „ (*Heterorthis*) *alternata*, Sowerby	*			
? „ (*Dinorthis*) *flabellulum*, Sowerby	*			
„ (? *Hebertella*) *keisleyensis*, sp. n.				
„ 2 spp. indet.				
Strophomena antiquata, Sowerby	*			
„ *corrugatella*, Davidson	*	*		
Leptæna rhomboidalis, Wilckens	*	*		
Rafinesquina expansa, Sowerby	*	...	*	
„ *deltoidea*	?	...	*	*
„ „ var. *undata*, M'Coy	*	?		
Plectambonites quinquecostata, M'Coy	*	*		
„ *Schmidti*, Törnquist	...	*	*	*
? „ *transversalis*, Wahlenberg	?			
Atrypa marginalis, Dalman	*			
„ *expansa*, Lindström	*	*		
„ „ var. *a*				
„ „ var. *β*				
„ „ var. *γ*				
Atrypina similis, sp. n.				
Christiania tenuicincta, M'Coy	*			
Streptis monilifera, M'Coy	*			
Triplecia insularis, Eichwald	*	...	...	*
Rhynchotrema cf. *dentatum*, Hall				
Syntrophia affinis, sp. n.				
Camerella ? *Thomsoni*, Davidson				
Hyattella Portlockiana, Davidson	*	*		
Dayia pentagonalis, sp. n.	*	*		
Obolella cf. *nitens*, Hisinger				
Orbiculoidea, 2 spp.				
? *Lingula*, sp.				

List of Fossils (*continued*).

Genera and Species.	Kildare Limestone.	*Leptæna*-Limestone.	Stage F.	
			Borkholm Zone.	Lyckholm Zone.
Polyzoa.				
Ptilodictya costellata, M'Coy ?	...	...	*	
„ *recta*, Hall ?	*			
Fenestella assimilis, Lonsdale	*			
Mollusca.				
Orthoceras cf. *elongatocinctum*, Portlock				
„ cf. *scabridum*, Angelin				
Loxonema striatissimum, Salter MS.	*			
Holopea concinna, M'Coy	*			
„ *striatella*, Sowerby				
Cyclonema rupestre, Eichwald	*	...	*	?
„ *sulciferum*, Eichwald	*			
Eunema carinatum, Lindström, var.	...	*		
Euomphalus cf. *obtusangulus*, Lindström	...	*		
? „ *subsulcatus*, Hisinger	*	*		
? „ *nitidulus*, Lindström	...	*		
Platyceras verisimile, sp. n.				
„ cf. *cornutum*, Hisinger				
? *Pleurotomaria notabilis*, Eichwald	...	...	*	
Murchisonia, sp. ?				
Conularia, sp.	*			
? *Hyolithus triangularis*, Portlock				
Pterinæa subfalcata, Conrad, var.				
Anodontopsis, sp.				
Modiolopsis, sp. ?				
Echinodermata.				
Sphæronites pyriformis, Forbes	*			
Crinoid stems, 6 spp.				
Actinozoa.				
Streptelasma europæum, Römer	...	...	...	*
Halysites catenularia, Linné	*	*	...	*
? *Heliolites dubia*, Schmidt	...	*	...	*
Stenopora fibrosa, Goldfuss	*			
Favosites alveolaris, Goldfuss, *pars*	*			
Prasopora Grayæ, Nicholson & Etheridge				
? *Nebulipora lens*, M'Coy				

General Remarks on the Fauna of the Keisley Limestone.

I. Trilobita.—The Trilobita are unmistakably the predominant members of the assemblage of organisms which we meet with in the Keisley Limestone. Not only in the number and variety of the genera and species do they far exceed other groups, but also in the number of individuals. Yet all the genera are not equal in this latter respect, nor are the species. The *Illæni* are the most common of all the trilobites, and large slabs covered with the head-shields and pygidia of *I. Bowmani* and its varieties are of frequent occurrence. *I. galeatus* is the next most common species of *Illænus*, while *I. Rœmeri*, *I. fallax*, and *I. cœcus* are very rare.

Next in order of abundance come the genera of Cheiruridæ, and in species and individuals they hold the same place. The species of *Pseudosphærexochus* and of *Sphærexochus* are represented by numerous individuals. The genus *Lichas* has at least six species belonging to it in this rock, but the individuals are not numerous. *Cyphoniscus socialis* is fairly abundant. From the failure of many observers and collectors to find such trilobites as *Staurocephalus Murchisoni*, of which I have myself collected at least a dozen specimens in a few hours, I believe the occurrence of such forms is sporadic or limited to special bands in the rock. It should be remembered that the great majority of the fossils recorded have been collected from loose blocks in the adjacent stone walls, or hammered out of detached masses lying on the surface of the ground. Many of those which I found were obtained from the remains of an old lime-kiln close to the large quarry, but others were chipped out of the outcropping solid rock.

The peculiar features of the trilobitic fauna are :—(1) The absence of the genera *Phacops* and *Trinucleus*. Both these genera are so abundant in the Bala rocks of all areas, and are represented by species so characteristic, that their entire absence is very striking. In the *Staurocephalus*-Limestone and Ashgill Shales, as well as in the underlying Middle Bala, we find them making a marked feature in the fauna. The genera *Trinucleus* and *Phacops* are practically absent from the Chair of Kildare Limestone[1] and the *Leptæna*-Limestone. *Trinucleus* is very rare in the Russian Stage F,[2] and till recently was thought not to occur there. (2) The occurrence of certain peculiar genera of very limited range in time and space, as, for example, *Cyphoniscus* and *Tiresias*. (3) The occurrence of many peculiar species limited either entirely to this Keisley bed, or to it and the Chair of Kildare Limestone, or to both these beds and the *Leptæna*-Limestone of Dalecarlia, or to the Keisley and Dalecarlian beds, or to one of these beds and Stage F of the East Baltic provinces of Russia.

[1] Quite recently Mr. C. I. Gardiner, F.G.S., has shown me an eye of a *Phacops* and a fragment of a *Trinucleus*—possibly *Tr. seticornis* (His.)—from the Kildare Limestone; but these are the only specimens I know.

[2] Fr. Schmidt, 'Rev. ostbalt. Silur. Trilob.,' pt. iv. Mém. Acad. Imp. des Sci. St. Pétersbourg, ser. 7, vol. xlii. (1894) no. 5, p. 71.

It will be seen on examining the list of fossils tabulated on p. 85 that, out of the total number of 40 species of trilobites in the Keisley Limestone, 20 are definitely known to occur in the Kildare Limestone, and 6 others are doubtfully recorded.

The following species also, so far as is known, are absolutely peculiar to these two limestones:—*Cheirurus keisleyensis*, *Ch. cancrurus*, *Sphærexochus latirugatus*, *Lichas bulbiceps*, *Tiresias insculptus*, *Cyphaspis* (*Törnquistia*) *Nicholsoni*, and *Cyphoniscus socialis*.

In the *Leptæna*-Limestone 10 or perhaps 12 of the Keisley species are found, and in the Borkholm and Lyckholm zones 3 (or 4) and 6 have respectively been recorded. Only a very poor list of the fauna of the Borkholm zone is obtainable,[1] or probably the number of common species would have to be increased. Moreover, if we take into account the closely-allied but not identical species of these beds, the similarity of the trilobitic faunas is still more marked. Thus *Cheirurus bimucronatus* and *Ch. keisleyensis* are allied to *Ch. insignis* and *Ch. speciosus* of the *Leptæna*-Limestone; *Ch.* (*Ps.*) *subquadratus* to *Ch.* (*Ps.*) *Rœmeri* of the Borkholm and Lyckholm zones; *Lichas bifurcatus* to *L. margaritifer* of the *Leptæna*-Limestone and Borkholm zone; *Acidaspis convexa* to *A. evoluta* of the *Leptæna*-Limestone; and *Illœnus Bowmani* to *I. Linnarssoni*, of the *Leptæna*-Limestone and the Borkholm and Lyckholm zones.[2]

The occurrence of many peculiar species of trilobites is very noticeable. *Cheirurus* (*Pseudosphærexochus*) *conformis* occurs in the above-mentioned beds in each area, and it might well be taken as the zone-fossil of this horizon.

The following species which are found at Keisley also are markedly characteristic of, or limited to, the *Leptæna*-Limestone, and therefore deserve special notice:—*Cheirurus glaber*, *Ch.* (*Pseudosphærexochus*) *conformis*, *Sphærocoryphe granulata* (?Keisley), *Harpes Wegelini*, *H. costatus* (? Keisley), *Homalonotus*? *punctillosus*, *Illœnus fallax*, and *I. Rœmeri*.

The following species have been so far found only at Keisley; although two of them are doubtfully recorded from Kildare:—

Cheirurus (*Pseudosphærexochus*) *subquadratus* (? Kildare), *Lichas bifurcatus* (? Kildare), *Cyphaspis*? *Harknessi*, *Ampyx binodulosus*, *Acidaspis convexa*, and *Illœnus galeatus*.

Turning now to the question of the degree of relationship of the trilobitic fauna of Keisley to that of the Middle and Upper Bala of Great Britain, we find the following species occurring in Middle Bala rocks:—*Cheirurus bimucronatus*, *Ch. clavifrons*, Dalm.?,

[1] Schmidt, 'Rev. ostbalt. Silur. Trilob.,' pt. i. Mém. Acad. Imp. des Sci. St. Pétersbourg, ser. 7, vol. xxx. (1881) no. 1, p. 38; and Quart. Journ. Geol. Soc. vol. xxxviii. (1882) p. 514.

[2] Several of the Kildare trilobites, not hitherto found at Keisley, occur in Stage F of the Baltic provinces, thus linking these widely-separated beds more closely together; see S. H. Reynolds & C. I. Gardiner on 'The Kildare Inlier,' Quart. Journ. Geol. Soc. vol. lii. (1896) p. 587.

Calymene Blumenbachi, var. *Caractaci*, *Sphærexochus mirus*, *Illænus Bowmani*, *Lichas laxatus*.

In the Upper Bala beds the following Keisley species are found:—*Cheirurus bimucronatus*, *Ch. clavifrons*, (?) *Sphærexochus mirus*, *Lichas laxatus*, *Illænus Bowmani*, **Remopleurides longicostatus*, **Phillipsinella parabola*, *Staurocephalus Murchisoni*, and *Calymene Blumenbachi*.

Of these the two species marked * are in Britain known only in the Upper Bala (excepting, of course the Kildare and Keisley Limestones). *Ch. bimucronatus*, *Sph. mirus*, *C. Blumenbachi*, and *St. Murchisoni* pass up into the Silurian. *Lichas hibernicus*, curiously enough, occurs elsewhere only in the Craighead Limestone of Scotland. *I. Bowmani* and *Sph. mirus* also occur in the Scottish Lower Bala.[1]

Thus, of the 10 species found in other British rocks, 3 occur in the Lower Bala, 6 in the Middle Bala, 9 in the Upper Bala, and 4 pass up into the Silurian. But in spite of this apparent great resemblance to the Upper Bala, we must remember that the absence of all species of *Trinucleus* and *Phacops*, especially *Tr. seticornis* and *Ph. eucentra*, characteristic forms of the Upper Bala,[2] marks an important difference.

Summing up, we obtain the following percentage results with respect to the species of trilobites from Keisley:—

(i) 50 % occur in the Kildare Limestone.
(ii) 25 % occur in the *Leptæna*-Limestone.
(iii) 25 % occur in British Bala or Silurian beds, and of these about 99 % occur in Upper Bala beds.
(iv) Over 70 % occur in no other British bed.
(v) About 16 % are peculiar to the Keisley Limestone.

The peculiarity of the trilobitic fauna of this bed is thus plainly shown.

II. Ostracoda.—Both the Keisley species occur at Kildare, and these are the only two localities in which one form (*Cythere Wrightiana*) is known to occur, while *Primitia M'Coyi*, the other species, is known elsewhere from the limestone of Aldeans on the Stinchar River.[3]

III. Brachiopoda.—The foregoing list of the fossils of the Keisley Limestone shows (p. 86) that out of the 37 species of brachiopoda, 19—or over 50 %—are also found at Kildare, and several others probably occur. In the *Leptæna*-Limestone[4] 12 of

[1] Nicholson & Etheridge, 'Mon. Silur. Foss. Girv.' 1879; Lapworth, Quart. Journ. Geol. Soc. vol. xxxviii. (1882) p. 537.

[2] Marr & Roberts, Quart. Journ. Geol. Soc. vol. xli. (1885) p. 476.

[3] Ann. Mag. Nat. Hist. ser. 4, vol. ii. (1868) p. 56.

[4] In the case of the *Leptæna*-Limestone I have made use of the specimens in the Woodwardian Museum, Törnquist's list in 'Öfvers. ö. Bergbygn. in Siljans. i Dal.' p. 26, Sveriges Geol. Undersökn. ser. c, no. 57, and the 'List of the Fossil Faunas of Sweden,' published by the Stockholm Museum in 1888.

the Keisley species, or over 30 % of the whole number of Keisley brachiopoda, have been recognized.

Schmidt mentions only 11 species of brachiopoda from the Lyckholm zone,[1] but of these 5 occur at Keisley. Out of the 10 species mentioned by him (*loc. cit.*) from the Borkholm zone, 4 occur at Keisley. Other species allied to British forms are recorded by him from these rocks. Thus we see that there is a considerable degree of similarity in the brachiopodal faunas.

Atrypa expansa and *Orthis conferta* appear confined to this horizon as represented at Keisley, the Chair of Kildare, Dalecarlia, and Western Russia. *Plectambonites Schmidti* is highly characteristic of it, though also known from the *Trinucleus*-shales of Sweden, while *Hyattella Portlockiana* has elsewhere been recorded only from 'the Upper Llandeilo' of Balcletchie, Girvan.[2] *Streptis monilifera*, apart from Kildare and Keisley, is mentioned by Davidson only from the 'Middle Llandovery' of Woodland Point,[3] Girvan.

Three species are peculiar to the Keisley Limestone:—*Orthis keisleyensis*, *Syntrophia affinis*, and *Atrypina similis*.

The commonest species of brachiopoda at Keisley are *Atrypa expansa* (and its varieties), *Strophomena corrugatella*, and *Christiania tenuicincta*.

The following Keisley species are found also in the Middle Bala of England, Wales, and Scotland:—

Orthis calligramma, *O. Actoniæ*, *O. biforata*, *O. biloba*, *O. alternata*, *O. elegantula*, *O. flabellulum*, *O. testudinaria*, *O. vespertilio*, *Triplecia insularis*, *Strophomena antiquata*, *Str. corrugatella*, *Rafinesquina deltoidea*, *R. expansa*, *Leptæna rhomboidalis*, *Christiania tenuicincta*, *Plectambonites transversalis*, *Pl. quinquecostata*, (?) *Camerella? Thomsoni*.

Thus over 50 % of the Keisley species occur in the Middle Bala.

Of the species occurring in the Upper Bala (*i. e.* the beds above and including the *Staurocephalus*-Limestone) it is difficult to draw up a satisfactory list, as the fossils have been by no means well investigated. From lists given by Mr. Marr and others[4] and from specimens at Cambridge we see that the following Keisley forms occur in the Upper Bala:—*Orthis Actoniæ*, *O. biforata*, *O. calligramma*, *O. elegantula*, *O. testudinaria*, *O. vespertilio*, *Christiania tenuicincta*, *Leptæna rhomboidalis*, *Plectambonites quinquecostata*.

This list is, I believe, much too short, and represents therefore imperfectly the degree of affinity of the brachiopodal faunas.

[1] 'Rev. ostbalt. Silur. Trilob.,' pt. i. Mém. Acad. Imp. des Sci. St. Pétersbourg, ser. 7, vol. xxx. (1881) no. 1, p. 38; and Quart. Journ. Geol. Soc. vol. xxxviii. (1882) p. 514.

[2] Davidson, 'Mon. Brit. Foss. Brach.' vol. v. (1882–84), Sil. Suppl. p. 159.

[3] *Ibid.* p. 147.

[4] Quart. Journ. Geol. Soc. vol. xxxiv. (1878) p. 871, vol. xli. (1885) p. 476, vol. xlvii. (1891) p. 500; Geol. Mag. 1892, p. 97.

Page Unavailable

Page Unavailable

Page Unavailable

It is clear that the bed contains a fauna with Middle and Upper Bala rather than Lower Bala affinities; and the occurrence of the species *Staurocephalus Murchisoni*, *Phillipsinella parabola*, *Remopleurides longicostatus*, and *Sphæronites pyriformis*, which do not range down below the Upper Bala, points to the inclusion of the bed in the Upper Bala. The presence of some Silurian species might incline us to assign to the Keisley Limestone a somewhat high position in the Upper Bala; but on comparing the lists of the fossils from the *Staurocephalus*-zone and the Ashgill Shales in England and Wales with the list from the Keisley bed, it is at once apparent that the relationship is much closer with the former than with the latter.

Thus, in the *Staurocephalus*-zone, we find the following Keisley species present:—

Remopleurides longicostatus.
Illænus Bowmani.
Lichas laxatus.
Phillipsinella parabola.
Cheirurus bimucronatus.
„ *juvenis* (=*clavifrons*, ? Dalm.)
Staurocephalus Murchisoni.
Sphærexochus mirus.
Christiania tenuicincta.
Orthis calligramma.
„ *elegantula.*
„ *testudinaria.*
Leptæna rhomboidalis.
Plectambonites quinquecostata.
Halysites catenularia.
Stenopora fibrosa.

In the Ashgill Shales and Redhill Beds, on the other hand, only the following Keisley species are present:—

Calymene Blumenbachi.
Cheirurus clavifrons.
Orthis Actoniæ.
„ *alternata.*
„ *biforata.*
„ *calligramma.*
Orthis elegantula.
„ *testudinaria.*
„ *vespertilio.*
Leptæna rhomboidalis.
Christiania tenuicincta.
Holopea concinna.

The argillaceous instead of calcareous nature of the sediment, and the different conditions of deposition, undoubtedly have much to do with the different facies of the Ashgill Shale fauna. There are, however, certain marked deficiencies in the Keisley Limestone fauna when we compare it with any part of the Upper Bala. Thus the genus *Trinucleus* is completely wanting, though *Tr. seticornis* is a characteristic trilobite of the whole Upper Bala throughout England and Wales. The two typically Ashgill Shale brachiopods, namely, *Orthis protensa* and *Strophomena siluriana*, are also conspicuous by their absence. The genus *Phacops* is completely absent from Keisley, so far as is known, though this genus is very rich in species and individuals throughout the Middle and Upper Bala elsewhere.

The affinities of the Keisley Limestone fauna with that of the Slade Beds and Hirnant Limestone are too remote to necessitate entering into the question here.

Full weight must be given to the large number of peculiar species found in the Keisley Limestone. Thus, of its well-determined species, omitting all those about which there is any doubt, 11 are absolutely peculiar to it, and 14 others are nowhere else found in the United Kingdom except in the Kildare Limestone.

The possession of so many peculiar forms stamps the fauna with a distinct individuality and strongly differentiates it from all other British beds.

Summing up, therefore, the palæontological evidence with reference to its stratigraphical position, we find: (1) that the fauna has a thoroughly Ordovician facies; (2) that it possesses a large number of peculiar species; (3) that while possessing a considerable number of Middle Bala species, yet the presence of certain forms known elsewhere only from or only commencing in the Upper Bala Beds points to a closer relationship to the latter than to the Middle Bala; (4) that the affinity of the fauna is much closer with that of the *Staurocephalus*-zone than with that of the overlying Ashgill Shales; (5) that the presence of so many peculiar forms, as well as the absence of certain typical species of the *Staurocephalus*-zone, precludes us from considering the Keisley Limestone and *Staurocephalus*-zone to be on exactly the same horizon, while the presence of a number of Middle Bala forms inclines us to put the Keisley Limestone slightly below rather than above the *Staurocephalus*-zone.

Thus it is at the bottom of the Upper Bala that on the strength of the palæontological evidence I would put the Keisley Limestone. Mr. Marr has arrived at nearly the same conclusion,[1] for he says that its fauna distinctly belongs to a lower horizon than the Ashgill Shales, and he would place it immediately below the *Staurocephalus*-Limestone as the uppermost bed of the Applethwaite Beds of the Sleddale Group of the Coniston Limestone Series, that is, at the top of the Middle Bala.

Sedgwick and Salter[2] assigned the fossils from this bed to the Middle Bala group.

Irish and Continental Equivalents.

Throughout the preceding description of the fauna of the Keisley Limestone frequent reference has been made to the Chair of Kildare Limestone, the *Leptæna*-Limestone of Dalecarlia, and the Borkholm and Lyckholm zones, which constitute Schmidt's Stage F of the East Baltic provinces of Russia, and many of the Keisley species have been mentioned as occurring in one or more of these beds. A brief summary of the common species will bring out the close relationship of these beds clearly. Unfortunately, only in the case of the Kildare and *Leptæna* Limestones has the fauna been to any extent adequately worked out, and even in these two cases there is room for a further scrutiny. The lists of fossils from the Borkholm and Lyckholm beds are very meagre. Schmidt,[3] however, states that the Swedish *Leptæna*-Limestone of the Osmundsberg in Dalarne which he visited seems perfectly identical with the white Bork-

[1] Geol. Mag. 1892, pp. 97 & 445.
[2] Cat. Cambr. & Sil. Foss. Woodw. Mus. (1873) p. 54, etc.
[3] Quart. Journ. Geol. Soc. vol. xxxviii. (1882) p. 514; [quoted by Linnarsson], Zeitschr. d. Deutsch. geol. Gesellsch. vol. xxv. (1873) pp. 696–697.

holm Limestone, and he regards them as formed at the same time in the same ocean. To support this view he quotes a list of identical fossils from the same bed, amongst which we notice several species which are not found on higher or lower horizons in those districts. It is on this occurrence of peculiar species of very limited vertical range that we must depend for the correlation of beds in distant lands, as is notoriously exemplified by the graptolites and Ammonoidea.

The homotaxial equivalence of the Keisley Limestone with that of Kildare is practically proved by the occurrence in both of the following species (List I.), which are unknown from any other beds in the British Isles. The presence also of the many common species (enumerated in List II.) in these two limestones strongly supports this conclusion.

List I.

Cyphoniscus socialis.
Cyphaspis (Törnquistia) Nicholsoni.
Cheirurus cancrurus.
„ *keisleyensis.*
„ (*Pseudosphærexochus*) *conformis.*
? „ („) *subquadratus.*
Sphærexochus latirugatus.
? *Sphærocoryphe granulata.*
Lichas bulbiceps.
? „ *bifurcatus.*
Tiresias insculptus.
Homalonotus punctillosus.
Illænus fallax.
? „ *Rœmeri.*
? „ *cœcus.*
Harpes Wegelini.
Cythere Wrightiana.
Atrypa expansa.
Fenestella assimilis.
Loxonema striatissimum.
Cyclonema rupestre.
„ *sulciferum.*

List II.

Cheirurus bimucronatus.
? „ *clavifrons?*
Sphærexochus mirus.
Staurocephalus Murchisoni.
Lichas laxatus.
„ *hibernicus.*
Illænus Bowmani.
Remopleurides longicostatus.
Primitia M'Coyi.
Atrypa marginalis.
Orthis Actoniæ.
? „ *alternata.*
„ *biforata.*
„ *calligramma.*
„ *flabellulum.*
? „ *testudinaria.*
„ *vespertilio.*
Rafinesquina deltoidea, var.
Rafinesquina expansa.
Strophomena corrugatella.
„ *antiquata.*
Leptæna rhomboidalis.
Plectambonites quinquecostata.
? „ *transversalis.*
Christiania tenuicincta.
Streptis monilifera.
Triplecia insularis.
Hyattella Portlockiana.
? *Ptilodictya recta.*
? *Euomphalus subsulcatus.*
Holopea concinna.
Conularia, sp.
Sphæronites pyriformis.
Favosites alveolaris.
Stenopora fibrosa.
Halysites catenularia.

Turning now to the *Leptæna*-Limestone of Dalecarlia we see that the following species, peculiar to that rock in Sweden, occur at Keisley. Those marked with an asterisk are doubtful at Keisley.

Cheirurus glaber.
Lichas conformis (var. at Keisley).
**Harpes costatus.*
„ *Wegelini.*
Homalonotus punctillosus.
**Euomphalus nitidulus.*
Euomphalus obtusangulus.
Eunema carinatum.
**Orthis conferta.*
Dayia pentagonalis.
Atrypa expansa

In addition to the foregoing the following Keisley species occur in the *Leptæna*-Limestone :—

Cheirurus (*Pseudosphærexochus*) *conformis*.
Sphærexochus mirus.
**Sphærocoryphe granulata*.
Lichas affinis.
„ *laxatus*.
Illænus fallax.
„ *Rœmeri*.
Orthis Actoniæ.
„ *biforata*.
Orthis biloba.
„ *calligramma*.
Strophomena corrugatella.
Leptæna rhomboidalis.
? *Rafinesquina deltoidea*, var. *undata*.
Plectambonites Schmidti.
? „ *quinquecostata*.
Hyattella Portlockiana.
**Heliolites dubia*.
Halysites catenularia.

The allied but not identical species need not again be mentioned. The evidence already adduced is sufficient to show the homotaxial equivalence of the beds.

With regard to the Russian beds Schmidt, as above mentioned, has insisted that the *Leptæna*-Limestone is on the same horizon as his Borkholm zone. It is confirmatory of my conclusions as to the homotaxial equivalence of these beds that several Kildare fossils which do not occur elsewhere in the British Isles are identical with species from these Russian beds ; as, for example, *Lichas lævis* (Eichw.) and *L. margaritifer* (Nieszk.).

The difficulty as to the stratigraphical position of the *Leptæna*-Limestone, indeed, enters into the above correlation. The divergence of opinion on this point is well known. Briefly, one party, respresented by Törnquist, places the *Leptæna*-Limestone above the *Retiolites*-Shales ; the other party, to which Schmalensee, F. Römer, and Marr belong, put it immediately above the *Trinucleus*-Beds and below the *Rastrites*-Shales. I am not in a position to criticize these two views, nor is this the occasion to do so, but I may point out that Schmidt has indisputably established the stratigraphical position and relations of the Borkholm zone in a region in which the succession of the beds is not confused or indistinct from deformation or dislocation of the strata ; that he has proved it to be at the top of the Ordovician System, and its fauna to be essentially identical with that of the *Leptæna*-Limestone.

Törnquist [1] has given the reasons for his view of the case in a number of valuable papers. Marr [2] at first went with him, but in 1885 [3] rejected that view, although he expressed the opinion that the *Leptæna*-Limestone contained ' a mixture of faunas of several of the Haverfordwest beds, viz. the Lower Llandovery, the *Trinucleus seticornis*-beds, and perhaps even of the Robeston Wathen Limestone.'

[1] ' Om Lagerfölj. i. Dal. undersil. Bildning.,' K. Vetensk. Akad. Förhandl. 1867 ; ' Geol. Iakt. o. d. Kambr. o. Silur. Lagf. i. Siljans.' Öfv. K. Vetensk. Akad. Förhandl. 1871, no. 1 ; 'Om Siljans. Pal. Format.' *ibid.* 1874, no. 4, p. 3 ; ' Berättelse, etc.' *ibid.* 1879, no. 2 ; Geol. Fören. i Stockholm Förhandl. no. 90, vol. vii. (1884) pt. 6, p. 304 ; *ibid.* vol. viii. (1886) ; *ibid.* vol. xiv. (1892), nos. 141, 147, etc.

[2] Quart. Journ. Geol. Soc. vol. xxxviii. (1882) p. 313.

[3] *Ibid.* vol. xli. (1885) p. 489.

Schmalensee[1] has expressed the view that the *Leptæna*-Limestone corresponds with the horny Klingkalk immediately above the *Trinucleus*-Shales, and Marr[2] likewise says that the Keisley Limestone may be represented by a white horny limestone seen in the stream at the Upper Bridge, Skelgill Brook, containing large *Orthocerata* and occurring immediately below the *Staurocephalus*-Limestone. Nathorst[3] illustrates this view of the occurrence of the *Leptæna*-Limestone by a diagram showing the local swelling-out of a thin band of limestone into a thick reef-like mass. Ferd. Römer,[4] on palæontological grounds, adopts the view that the *Leptæna*-Limestone is at the upper limit of the Lower Silurian [=Ordovician]; and Holm[5] and Andersson,[6] more recently, do the same.

It may be noticed here that several of the species limited in Sweden to the *Leptæna*-Limestone, in England to the Keisley Limestone, and in Ireland to the Chair of Kildare Limestone occur in the East Baltic provinces, not only in the Borkholm Limestone, which Schmidt[7] correlates exactly with the *Leptæna*-Limestone, but also in the underlying Lyckholm zone. Thus *Pseudosphærexochus conformis*, *Cheirurus* cf. *glaber*, *Cybele brevicauda*,[8] *Harpes Wegelini*, *Lichas dalecarlicus*, *Bronteus laticauda*, and *Heliolites dubia* are recorded among others by Schmidt[9] from the Lyckholm zone, but in Sweden for the first and only time from the *Leptæna*-Limestone. Schmidt[10] indeed says that the Lyckholm and Borkholm zones are so closely allied in their faunas that they cannot be separated at present as distinct stages. Yet, on the other hand, though he considers his Stage F to represent 'the British Caradoc Sandstone and the Coniston and Craighead Limestones,' it is remarkable that so many of its typical species do not occur in Britain till the Keisley Limestone, which we have been led to place at the base of the Upper Bala—e. g. *Pseudosphærexochus conformis*, *Cheirurus* cf. *glaber*, *Illænus Rœmeri*, *I. cæcus*, *Harpes Wegelini*, *Plectambonites Schmidti*, *Cyclonema rupestre*, *Pleurotomaria notabilis*. It is also noticeable that several Keisley Limestone species are very closely allied to forms not occurring in lower beds in Britain, but in lower beds in Scandinavia. Of these the following are examples:—*Cheirurus keisleyensis*, which is allied to *Ch. subulatus* of the *Trinucleus*-Schists, and *Cyphaspis Nicholsoni*, which so much resembles *Trilobites trira diatus* of the same beds.

[1] 'Om Leptænak. Plats i Silur. Lag.' Geol. Fören. i Stockh. Förhandl. no. 89, vol. vii. (1884), pt. 5, p. 280; *ibid.* no. 146, vol. xiv. (1892), pt. 6, p. 497.

[2] Geol. Mag. 1892, p. 97.

[3] 'Någr. o. o. Slipsandst. i. Dal.' Geol. Fören. i Stockh. Förhandl. no. 93, vol. vii. (1884) pt. 9, p. 559.

[4] 'Lethæa Erratica,' Paläont. Abhandl. Berlin, vol. ii. (1885) pt. v. p. 72.

[5] Sveriges Geol. Undersökn. ser. c, no. 115, pp. 14, 15, Stockholm, 1890.

[6] Öfvers. K. Sv. Vet. Akad. Förhandl. 50 Årg. p. 571, Stockholm.

[7] Quart. Journ. Geol. Soc. vol. xxxviii. (1882) p. 514.

[8] This species is stated by Schmidt to occur also in his Stage E.

[9] 'Rev. ostbalt. silur. Trilob.,' pt. i. Mém. Acad. Imp. des Sci. St. Pétersbourg, ser. 7, vol. xxx. (1881) no. 1.

[10] Quart. Journ. Geol. Soc. vol. xxxviii. (1882) p. 514.

Sphærocoryphe granulata, *Illænus Rœmeri*, and *Plectambonites Schmidti* occur in the *Trinucleus*-Schists of Sweden as well as in the *Leptæna*-Limestone, but are known only from the Keisley Limestone in Britain. *Illænus fallax*, found only at Keisley and Kildare in the United Kingdom, occurs as low down as the *Chasmops*-Limestone in Sweden.

These facts appear to indicate that the species developed at an earlier period in Eastern Europe, and thence migrated in a westerly direction. Marr [1] has pointed to similar evidence in the case of the Cystidean and *Orthoceras*-Limestones of Sweden and Russia.

Mode of Occurrence and Characters of the Keisley Limestone.

The Keisley Limestone occurs as an isolated mass of limestone on the western side of the southern end of the Cross Fell inlier. The earliest mention of it is in a paper by Buckland [2] in 1807. Recently its relations have been described in brief by Marr & Nicholson.[3] The narrow elongated area which it occupies is bounded on all sides by faults, and in no neighbouring locality is a limestone with similar characters, thickness, and fossils known to exist. Consequently, its exact stratigraphical relations and horizon have been a matter of much dispute. The lithological characters of the rock are by no means simple or uniform. The mass in fact appears to consist of several more or less well-marked types, or perhaps beds, of limestone with thin subsidiary shaly layers.

Thus, lithologically, we may distinguish the following more or less distinct varieties of the limestone: (1) a pale pink, fine-grained, compact, homogeneous limestone with comparatively few organic remains and no crinoid-stems; (2) a dark grey, bituminous, compact or crystalline limestone, likewise poor in fossils and devoid of crinoids; (3) a very coarsely crystalline, white or reddish-stained limestone full of the characteristic fossils and many crinoid-stems. The crystallization of the matrix in this case has extended to these included organic fragments, as described by Prof. Nicholson [4]; (4) a dark greyish compact limestone, not coarsely crystalline, crowded with *Orthoceras*, but containing few other genera of fossils; (5) a pale greyish crystalline limestone with many fossils. Other transitional varieties occur. Some layers of the limestone are full of *Illæni*, and a dozen or more head-shields and pygidia may be seen on a slab a foot or so square.

These varieties of texture and organic contents do not occur with

[1] Quart. Journ. Geol. Soc. vol. xxxvi. (1880) p. 279; vol. xxxviii. (1882) p. 313.

[2] Trans. Geol. Soc. ser. 1, vol. iv. pt. i. (1816) p. 105, pl. v., section, no. 3. In this paper the limestone is apparently considered to be of Carboniferous age.

[3] Quart. Journ Geol. Soc. vol. xlvii. (1891) p. 507.

[4] Nicholson & Lydekker, 'Manual of Palæontology,' 3rd ed. (1889) vol. i. p. 20, figs. 5*a*, 5*b*.

much regularity or allow themselves to be traced far laterally, but the greatest development of the dark bituminous, poorly fossiliferous variety is found in the large quarry on the hillside, which is still worked. This quarry lies at the foot of the hill, and shows a southerly to south-easterly dip of these beds. On the higher slopes the grey, pink, or coarsely crystalline varieties are met with, but whether they lie above or below the bituminous variety is doubtful.

The red-staining of some parts of the limestone is undoubtedly due to a comparatively recent oxidation of the contained iron, or possibly to the infiltration of chalybeate waters.

The patchy manner in which some of the varieties of limestone occur, even in the same hand-specimen, seems to point to original slight differences in the deposit or to segregation at local centres while the calcareous mud was soft. This 'patchiness' is especially noticeable in the case of the fine-grained pink variety of the limestone.

Some of the minute structural features are due to the dynamic agencies which have affected the rock.

Evidence of Disturbance.

Direct evidence of considerable mechanical disturbance of the limestone is afforded by the twisted wisps of shales included in the mass, as Marr & Nicholson have remarked (*loc. cit.*). In the old disused quarry, south of the one now worked, there may be seen a section of a partially overturned fold, and of what appears to be a thrust-plane, with considerable shattering and crushing of the rock along the gliding-surface.

Marr & Nicholson believe that the limestone has been thickened by the thrusting-up together of the calcareous portions and squeezing-out of the shaly layers by the action of a force acting from the south-west, and they mention that inversion of some of the beds appears indicated by the occurrence of *Illæni* with their convex surfaces downward. We must in fact regard the so-called Keisley Limestone as a series of thin limestone-bands separated by thinner shaly layers, which have been folded, crushed together, and forced over each other so as to present a spurious thickness.

Stratigraphical Considerations.

Since we are led to regard the thickness of the Keisley Limestone as largely due to mechanical deformation and not entirely to original deposition, and the obscurity of its relations as due to its isolation by faults, we might not unnaturally think that it was a block of the neighbouring strata squeezed up and displaced. This view, however, is seen to be utterly untenable when we ascertain the unique facies of the fauna and its dissimilarity to that of any other British beds (see *infra*). There is, however, an idea, which at first sight appears probable, that the Keisley Limestone is the sole remnant of what was once a widespread formation, which

Page Unavailable

Conditions of Deposition and Origin of the Fauna of the Keisley Limestone.

The isolation of the patch of limestone at Keisley has been fully emphasized, but, as already mentioned, Marr [1] is inclined to think that it is merely a very local development, under peculiar and very restricted conditions, of a thin limestone underlying the *Staurocephalus*-Limestone. A white horny limestone in Skelgill, and a similar limestone in Swindale Beck may be, in his opinion, the attenuated and lithologically-different representatives of the Keisley mass. He adduces cases in other districts with beds of various ages in which 'reefs' or lenticular masses of crystalline limestone occur on the same horizon as these horny limestones and in close connexion with them. Such is the case with some Devonian limestones near Torquay, with the Konieprus Limestone (Ff 2) in Bohemia, with the *Leptæna*-Limestone and Klingkalk of Dalecarlia (according to Nathorst [2]), with the 'knoll-reefs' described by Tiddeman,[3] of Carboniferous age, south of the Craven fault in West Yorkshire, and with some Devonian limestones of the Ardennes. In all these instances the district and rocks in which they occur have suffered great disturbance.

With regard to the Keisley Limestone, I am inclined to think that we may best explain the fact that it is not palæontologically represented elsewhere in the British Isles, except at Kildare, by supposing that a wave of migration started from the Baltic towards the close of Middle Bala times; that it travelled in a westerly direction over Scandinavia, the North of England, and into Ireland, but only in isolated spots—such as are now found in Dalecarlia, Keisley, and Kildare—did the fauna which it bore (namely, the fauna of Stage F of Western Russia) find the conditions suitable for its settlement. In the intervening areas it was unable to exist, at any rate in its entirety. Many of the species of the fauna of the seas which it invaded continued to flourish alongside of it, and contributed their remains to the formation of the limestone-patches. On the surrounding portions of the sea-floor, thin horny limestone accumulated in some parts, and in others shales, etc., but without the peculiar fauna. After an existence of brief duration in these isolated outposts, far removed from its original home, most of the fauna died out, mainly owing to the cessation of favourable conditions, but partly owing to the immigration of the new fauna of the *Staurocephalus*-zone. It left but few descendants behind it.

The facts in favour of the view that the existence of this fauna was largely conditional on the physical and biological environment are: (1) the presence of numerous specifically-identical forms, although the localities are so widely separated one from another; (2) the absolute limitation of many of these forms to these patches of limestone; (3) the occurrence of blind species of *Illænus* with

[1] Geol. Mag. 1892, p. 97.
[2] Geol. Fören. i Stockholm Förhandl. no. 93, vol. vii. (1884) p. 559.
[3] Rep. Internat. Geol. Congr. 1888, pp. 319–322.

common structural peculiarities; (4) the similar lithological character of the patches.

The evidence in favour of the brief duration of the fauna consists in (1) the comparatively slight change in the peculiar facies of the fauna, despite the considerable distance apart of the several localities; (2) the small development of local species or varieties; (3) the little impression that it has left on subsequent faunas.

So far, therefore, as our present knowledge goes, we may look upon this 'Stage F' fauna as presenting an example of discontinuous distribution. The period during which the area of distribution was continuous lasted only during the time necessary for the migration, and it was therefore so transient as to leave scarcely a trace behind in the intervening tracts between the few spots where the fauna was able to take root. These spots now alone indicate the size of the area over which the wave of migration spread.

The fact that the limestone in each of these 'outposts' or 'stations' has suffered so much mechanical disturbance may, perhaps, be in the main attributable to its reef-like nature and mode of occurrence, as a local thickening of an elsewhere thin band of rock. But I do not wish to generalize, or to imply that this suggested explanation applies to those examples of 'reefs' among Devonian and Carboniferous rocks which Mr. Marr has quoted (*loc. cit.*). Each case must be decided independently and on its own merits.

Summary and Conclusion.

As the result of the above detailed inquiry into the characters of the fauna of the Keisley Limestone and the relations of the rock, it appears to me that the following facts are established:—

(1) The fauna has a thoroughly Ordovician facies.
(2) It is closely comparable with that from the Chair of Kildare Limestone and that of the *Leptæna*-Limestone of Dalecarlia, and less closely with that of Stage F of the East Baltic provinces.
(3) Its palæontological features point to its stratigraphical position being at the base of the Upper Bala.
(4) It must be regarded as the locally-thickened development of a bed which is elsewhere in Great Britain very thin or entirely absent, or represented by beds of entirely different lithological characters containing a different fauna.
(5) The fauna has certain unique characters which mark it off from all other known assemblages of fossils in Great Britain.

Note.—Recently I have been informed by Mr. R. Clark, of the Geological Survey of Ireland, that the limestones of Toormakeady, Co. Mayo, Courtown, Co. Wexford, and Caherconree, Co. Kerry, are lithologically and palæontologically (so far as the fossils are known) identical with the Kildare Limestone. At present,

I have been unable, from lack of time, to confirm personally the accuracy of this statement, which I find also appears in the Geological Survey Memoirs dealing with those districts, but I intend to take the earliest opportunity of visiting these localities. The scanty lists of fossils from them which have appeared in the Explanations of Sheets 160, 161, etc. (1863), p. 12 (Caherconree); sheets 148, 149 (1887), pp. 21–24 (Courtown); sheets 73, 74, etc. (1876), pp. 28, 31, and 33; and sheets 93, 94, etc. (1878), p.114 (Toormakeady), certainly contain several of the Kildare species, and the specimens of the rocks which I have seen bear a remarkable resemblance to the Keisley and Kildare Limestones. If it be subsequently established by more minute investigation that these patches of limestone at Toormakeady, Courtown, and Caherconree are of the same age as that at Keisley, none of the conclusions arrived at in this paper will have to be rejected, but these three localities will have to be quoted as additional 'outposts' of this peculiar fauna.

EXPLANATION OF PLATE VI.

Fig. 1. *Orthis* (*Hebertella*?) *keisleyensis*, sp. n. Pedicle-valve. ×3.
1*a*. Outline of side view of pedicle-valve. ×3.
1*b*. Natural size.
2. *Atrypina similis*, sp. n. Pedicle-valve. ×3.
2*a*. Brachial-valve (young individual). ×3.
2*b*. Natural size.
3. *Atrypina similis*, sp. n. Brachial valve. ×3.
3*a*. Natural size.
4. *Syntrophia affinis*, sp. n. Pedicle-valve. ×3.
4*a*. Natural size.
5. *Dayia pentagonalis*, sp. n. Brachial valve. ×3.
5*a*. Pedicle-valve. ×3.
5*b*. Anterior margin of valves. ×3.
5*c*. Natural size.
6. *Loxonema striatissimum* (Salter MS.). Natural size.
7. *Platyceras verisimile*, sp. n. ×2.
7*a*. Side view. ×2.
7*b*. Natural size.
8. *Murchisonia*, sp. ×3.
8*a*. Natural size.
9. *Anodontopsis*, sp. ×3.
9*a*. Natural size.

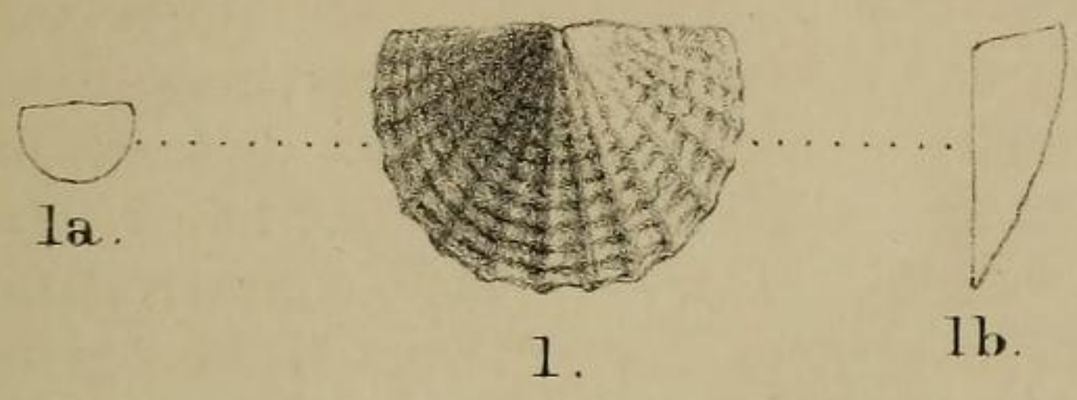
Discussion.

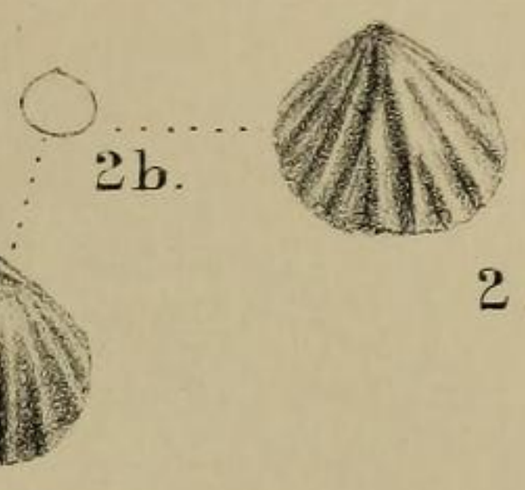
Mr. Marr could not, at the late period of the evening at which the paper concluded, say much upon the points where he agreed with the Author, so would speak at once regarding matters on which he disagreed. He doubted whether the limestones of Keisley were all upon one horizon, though there certainly was a very definite fauna intermediate between that of the Applethwaite Limestone and that of the *Staurocephalus*-Limestone; whether that fauna was referable to Middle or Upper Bala depended upon the line taken between these two groups—which had been originally separated one from another by Sedgwick on stratigraphical grounds, though he (the

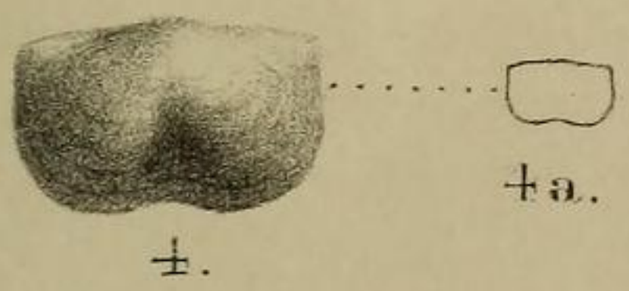
speaker) had attempted to define the base of the Upper Bala in Britain upon palæontological grounds. The Author was mistaken in saying that the speaker considered the Keisley Limestone a local development; what he did think was that its peculiar features at Keisley were due to subsequent earth-movement. Finally, he disputed the statement that *Trinucleus seticornis* was a characteristic Upper Bala fossil. The type (in Sweden) came from Middle Bala beds; it was very common in Middle Bala beds in Britain, and, so far as the speaker's experience went, rare in Upper Bala beds.

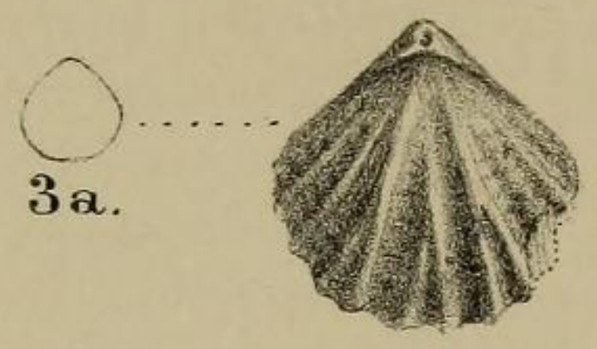
Dr. G. J. Hinde enquired of the Author whether he had compared the fauna of the Keisley Limestone with that of the Hudson River formation of Eastern North America, and more particularly with that shown on the Island of Anticosti. Judging from the specimens exhibited, it seemed to the speaker that there were several species common to these widely-separated areas.

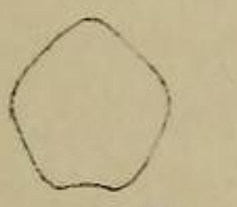
The Author, in replying to Mr. Marr, who objected to the use of percentages in determining the relations of faunas, held that percentages were merely a concise way of stating ascertained facts, and were only misleading when the special conditions and modifying circumstances of each case were left out of account. Mr. Marr also denied that *Trinucleus seticornis* was specially characteristic of Upper Bala beds, though some years ago he had called the Upper Bala beds of the Haverfordwest area after that fossil. From the examination of a very large number of so-called examples of this species from the Middle Bala, the Author could positively state that the great majority of them were quite distinct from the common form which bears this name in Upper Bala beds. He had had no opportunity of comparing the Keisley Limestone fauna with that of the Hudson River Group.

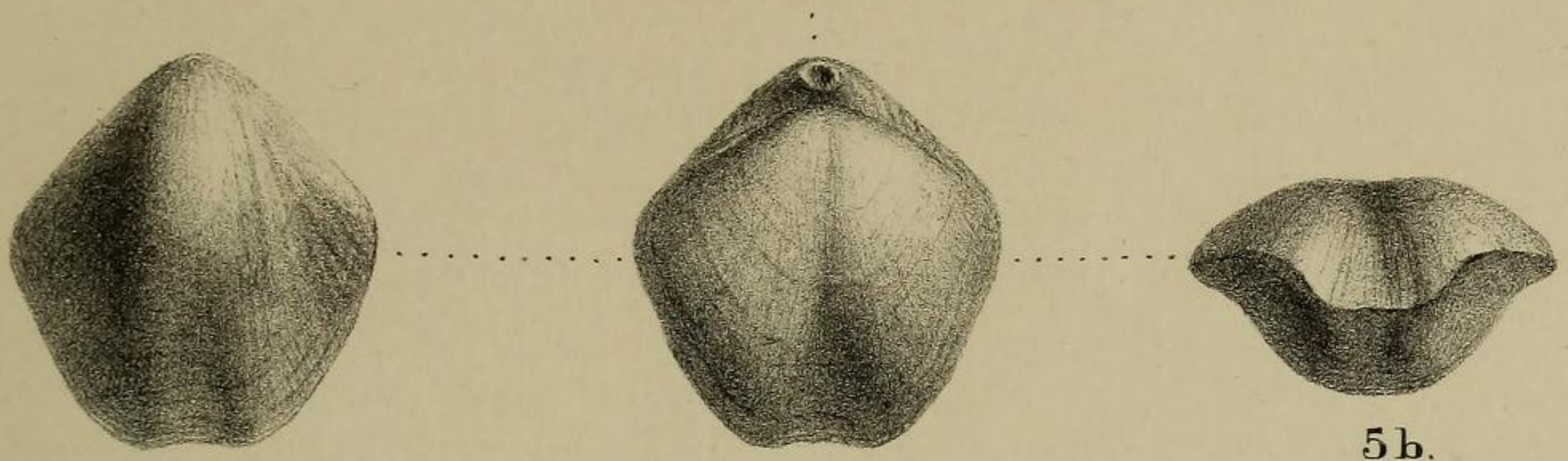


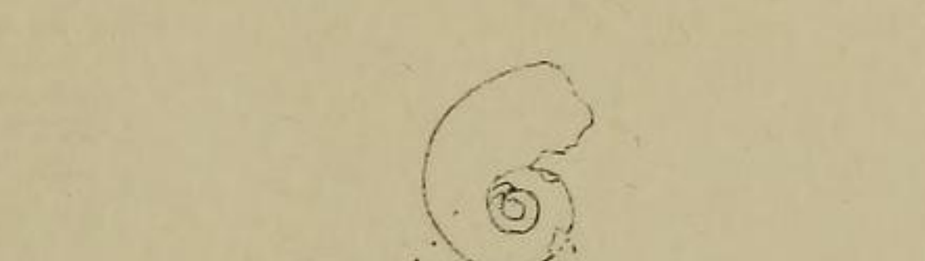


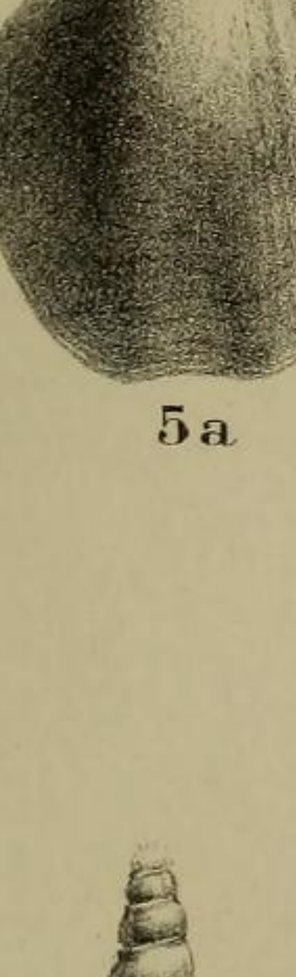


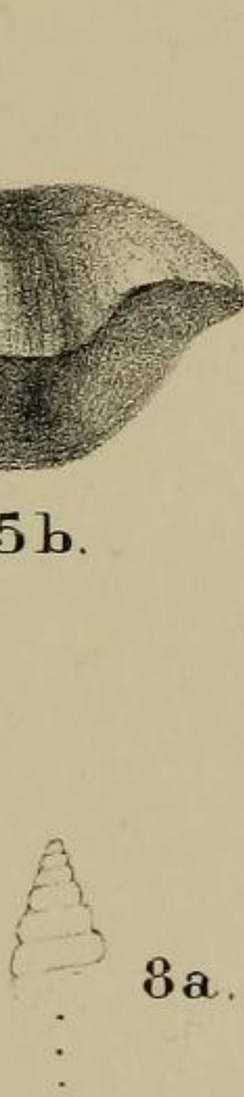


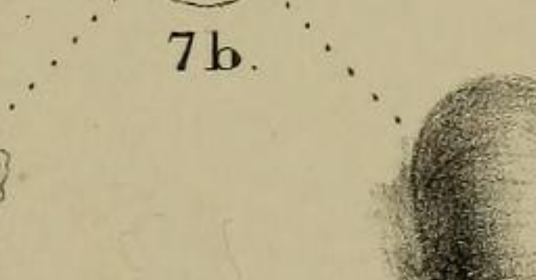












F.H. Michael del. et lith. Mintern Bros. imp.

BRACHIOPODA AND MOLLUSCA FROM THE KEISLEY LIMESTONE.